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DIGITAL DATA EDITING SYSTEM.(U)
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(6) DIGITAL DATA EDITING SYSTEM

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Lundy Electronics & Systems, Inc.
1 Robert Lane
Glen Head, N. Y. 11545

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Engineer Topographic Laboratories
Fort Belvoir, VA 22060

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Digital Data
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Interactive Displays

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A requirement within a computerized map and chart production process is editing of the digitized data prior to the final copy. This paper describes an off-line editing subsystem of the semi-automated cartography system developed by the U.S.Army Engineer Topographic Laboratory (USAETL) at Fort Belvoir and the Defense Mapping Agency (DMA) production centers.

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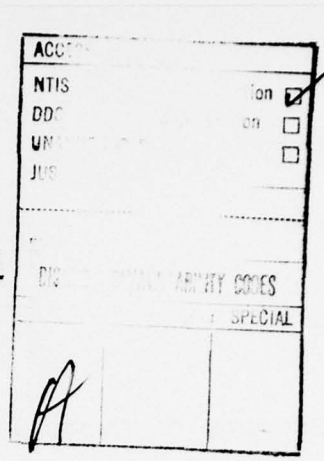


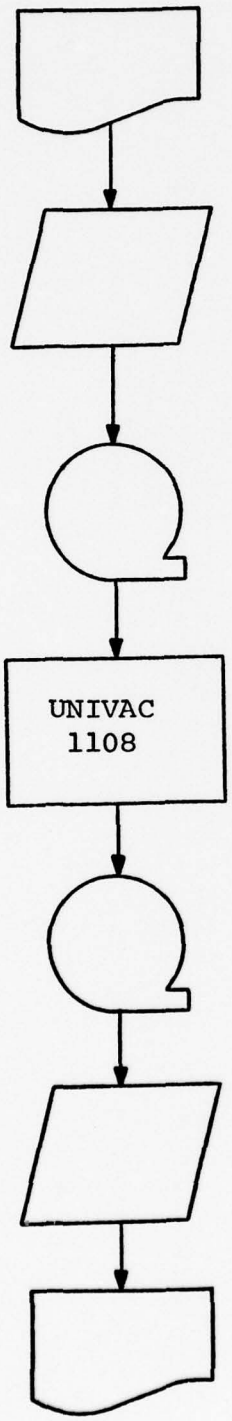
TABLE OF CONTENTS

TABLE OF CONTENTS
(CONTINUED)

LIST OF ILLUSTRATIONS

LIST OF TABLES

AUTOMATED CARTOGRAPHY SYSTEM



INPUT SOURCE MATERIAL

DIGITIZER

DIGITIZED FEATURE DATA

PROCESSING OF
DATA FILES

PLOTTER TAPE

X-Y PLOTTER

COLOR
SEPARATIONS

FIGURE 1

1.0 Introduction

Lundy Electronics & Systems, Inc. was awarded a contract for a system to provide the means of rapid editing of digitized cartographic data in a real time mode. The system is called the Digital Data Editing System (DDES) and has as its input unedited digitized map and chart data on magnetic tape. The data is displayed on the two system CRT displays for visual verification and edited by means of a digitizer tablet. The output of the system is edited map and chart data on magnetic tape to be further processed for production plotting on X-Y plotters.

This paper describes the DDES equipment, its function in a semi-automated cartography system, and testing of the equipment prior to delivery.

2.0 Background

Map and chart production by manual methods was a lengthy process. From the initial compilation of data from various source material to the final separation of color negatives took months of manual work.

The U. S. Army Engineer Topographic Laboratories at Fort Belvoir and the Defense Mapping Agency Production Centers have worked together in developing a semi-automated cartography system called SACARTS. This system was developed for the purpose of automating the drafting process of map and chart production.

The system is a computer process in which the input source material is digitized, formatted for color separation, and output onto X-Y plotters. Digitizing of input sources is performed by off line XYZ digitizers as the Stereocompilation Digitizer and the Digital Planimetric Compiler. Other types of digitizers may also be used in the system either manual tablet or drum scanner.

The data is compiled to a common format and file structure such that the data may be output to any type of plotter either flat bed or drum plotter. The flow of data is shown in figure 1. The result is five color separations and a

AUTOMATED CARTOGRAPHY SYSTEM WITH EDITING

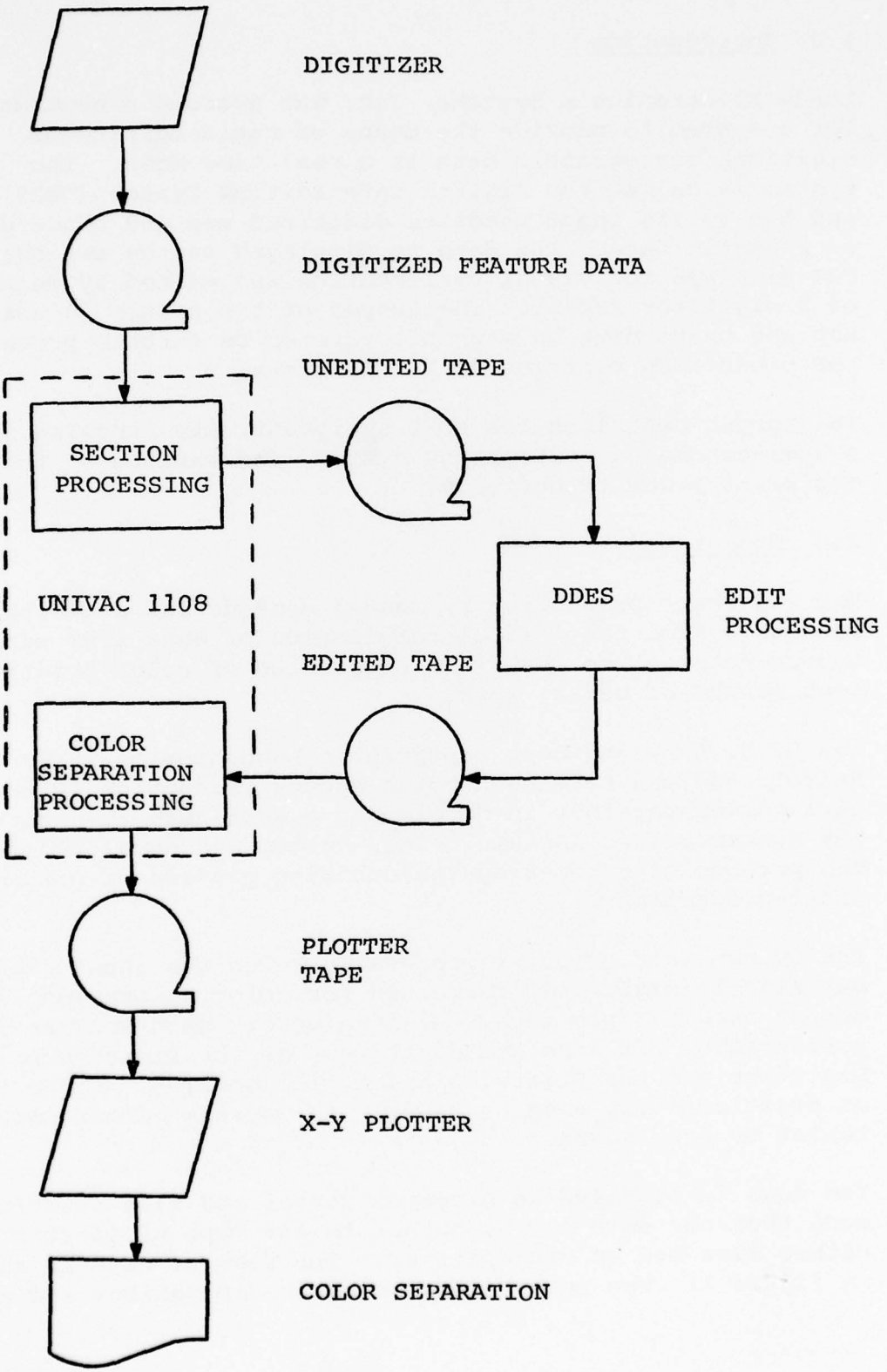


FIGURE 2

magnetic tape containing the digitized information to be stored for future production of the map or chart. Not shown in figure 1 is a means of revising the cartographic data after it is digitized. Invariably the need arises for revising portions of existing sheets due primarily to construction works of man such as new roads, buildings, and other features.

The most efficient means of incorporating an editing process in the system is a real time interactive system. A computer system that would 1. be independent of the map and chart processing computer, 2. allow the operator to digitize the added data and see the results instantly on the CRT displays without waiting for a XY plot to verify each change, and 3. compile the new data with the original data file as the changes are made. This editing system is the DDES shown in figure 2 in the flow process of the overall system.

3.0 Editing System Description

The components of DDES constitute a single system capable of rapidly editing segments of digital cartographic data. The equipment receives unedited data on either 7 or 9 track magnetic tape, displays the data on both storage CRT and refresh CRT, revises the data using digitizer, function keyboard and alphanumeric keyboard, and outputs the data onto 7 or 9 track magnetic tape. The magnetic tape is stored for future use or is further processed for production application on automatic cartographic drafting machines. A list of the equipment is shown in Table 1.

TABLE 1

DDES Hardware Components List

Model No.	Description	Quantity
PDP-11/45-FS	CPU with 32K Parity Core Memory, LA36-C DEC Writer II, DL11-A Terminal Controller, Memory Management and Cabinet	1
MF11-UR	32K Parity Core Memory Module	1

TABLE 1
(Continued)

Model No.	Description	Quantity
MF11-US	64K Parity Core Memory Module	1
KW11-P	Programmable Real-Time Clock	1
KW11-L	Line Frequency Real-Time Clock	1
BM873-YB	Bootstrap Loader	1
FP11-B	Floating Point Processor	1
RJP04-AA	44 Million Word Disk Pack Control and RP04 Drive	1
RP04-P	44 Million Word Disk Pack for RP04 Drive	2
TMA11-EA	9 Track Tape Transport and Controller	1
TU10-EE	9 Track Tape Transport	1
TU10-FE	7 Track Tape Transport	1
LP11-VA	Line Printer, 132 Column, 300 LPM	1
CR11	Card Reader, 300 CPM	1
H960-DH	Cabinet with single sliding extension mounting box	1
DD11-B	Peripheral Mounting Panel	2
BA11-KE	Rack Mountable Extension Mounting Box	1
DB11-A	Bus Repeater	1
4014-1	Tektronix Graphic Display Terminal with Enhanced Graphics, Minibus Extender, Interface for PDP-11 with a KL11 Controller and Desk Top Mounting Kit	1

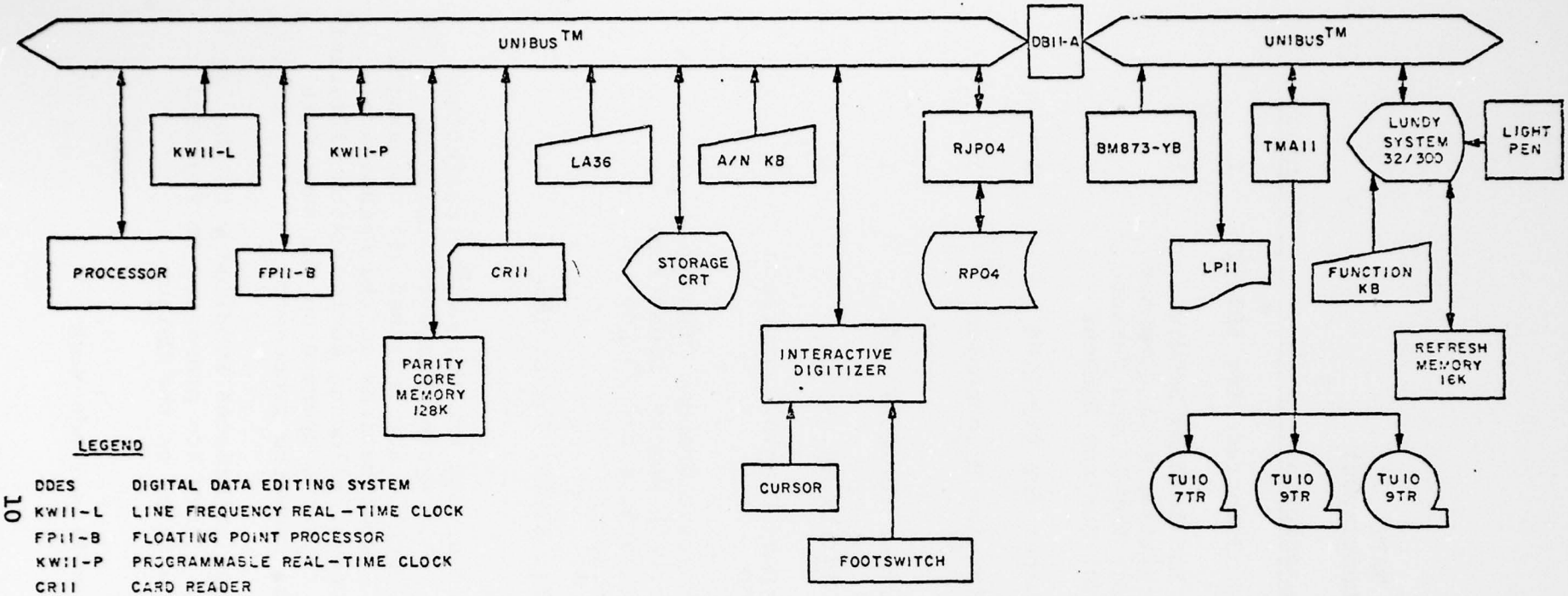
TABLE 1
(Continued)

Model No.	Description	Quantity
KL11-S	Asynchronous Interface for 4014-1	1
DTS-1.04	36x48 inch Backlighted Bendix Datagrid Digitizer with Computer Interface for PDP-11 and Cursor with five (5) Control Buttons	1
DTS-2.03	Control Cabinet for DTS-1.04	1
DTS-4.03	Stream Digitizing Electronics DTS-1.04	1
DTS-7.02B	Pen Type Cursor for DTS-1.04	1
DDS-8.05	Footswitch for DTS-1.04	1
DR11-C	General Purpose Digital Interface for DTS-1.04	1
System 32/300	Lundy Interactive Graphic Display with 16K Refresh Memory, Light Pen, Character Generator and 25 Key Function Keyboard	1
BC11A-25	Unibus Cable, 25 ft, for System 32/300	1

The equipment is configured around the Unibus[tm] architecture of the PDP-11/45 computer. All system elements including processor, memory and peripherals are accessed via the single structure of the Unibus. Communications on the Unibus are bidirectional and asynchronous, allowing devices with different input and output transfer rates to operate on the same data bus independent of distance from the processor.

All peripherals use standard interfaces supplied with the system by the manufacturer. They are presented in figure 3 in the sequence of their position on the Unibus.

tm=Digital Equipment Corporation Trade Mark



LEGEND

DDES	DIGITAL DATA EDITING SYSTEM
KW11-L	LINE FREQUENCY REAL-TIME CLOCK
FP11-B	FLOATING POINT PROCESSOR
KW11-P	PROGRAMMABLE REAL-TIME CLOCK
CR11	CARD READER
LA36	CONSOLE TERMINAL
A/N KB	ALPHANUMERIC KEYBOARD
RJP04	44M WORD DISK PACK CONTROL UNIT
RP04	44M WORD DISK PACK DRIVE
DB11-A	UNIBUS REPEATER
BM873-YB	BOOTSTRAP LOADER
LP11	LINE PRINTER
TMA11	MAGNETIC TAPE CONTROL UNIT
TU10	MAGNETIC TAPE TRANSPORT
SYSTEM 32/300	REFRESH CRT DISPLAY
TM	TRADEMARK OF DIGITAL EQUIPMENT CORPORATION

FIGURE 3. DDES PDP-11/45 CONTROLLER

3.1 Description of Peripherals

3.1.1 Line Frequency Real Time Clock, KW11-L

The real time clock may be operated in an interrupt or non-interrupt mode. During interrupt mode an interrupt occurs for each cycle of the line frequency. During non-interrupt mode, the Monitor bit of the Clock Status Register is checked and cleared for each cycle of the line frequency without causing an interrupt.

3.1.2 Programmable Real Time Clock, KW11-P

The programmable clock allows programmed real-time interval interrupts and interval counting in Single, Repeat and External Event Counter Modes.

3.1.2.1 Single Interrupt Mode

A count representing a time interval is entered into the counter. When the preset count is reached an interrupt is generated and the counter is reset to zero.

3.1.2.2 Repeat Interrupt Mode

Upon each interrupt described as a single interrupt the counter is reloaded and the clock restarted.

3.1.2.3 External Event Counter Mode

There are four (4) program selectable count or interrupt rates available, 100 kHz, 10 kHz, line frequency and external input.

3.1.3 Card Reader, CR11

The card reader consists of a table unit that accepts cards punched EIA standard Hollenrith code. The 12 row, 80 column cards are read at a rate of 300 cards/minute.

3.1.4 DECwriter II, LA36-C

The DECwriter II is the console terminal. It is used to type in or print out information at a rate of 30 characters/second with a buffer mode of 60 characters/second, when more than one character is in the 16 character buffer.

One of its functions within the editing system is to initiate or halt an editing operation. As the console terminal for a multi programming system, it may also execute background program development while a data editing operation is in progress.

3.1.5 Disk Controller and Drive (RJP04/RP04)

The RJP04/RP04 Controller/Drive system consists of a controller (RJP04), two small peripheral controller cards and a stand alone disk drive (RP04). The RP04 is a moving head, random access, multi surface, mass storage disk drive. All data transfers use the Non Processor Request mode of the Unibus for direct access to memory with transfer rates of 2.5μs/word. Capacity of a disk pack is 43,980,288 words.

Once the data files are entered into the system from magnetic tape, the files are transferred to the disk for storage. The disk furnishes the ability for random access of sections of the files for updating.

A second use of the disk is for temporary storage of CRT display files. In order to build display images the digital data file of point and centerline data must be restructured for the CRT displays. To minimize the time for changing images of the CRT, only that portion of the CRT display file is changed, eliminating the time required to recompute the complete data file.

3.1.6 High Speed Line Printer (LP11-VA)

The high speed line printer is a 132 column, 64 ANSCII character printer. It is an impact type with a revolving character drum.

During system development, one use of the line printer was for high speed output of program listings. Its use as a device in an editing system may be for verification of incremental center line data as in the digitizer test program BDXTST or for coordinate data of feature data files.

3.1.7 Magnetic Tape TMA11/TU10

The magnetic tape system consists of a controller and one 9-track tape transport in a self contained cabinet and two

additional tape transports (one 7-and one 9-track) in separate cabinets. The controller is capable of supporting a total of eight transports either 7-or 9-track.

The data format for 9-track tape is eight data bits and one vertical parity bit for each data character. A data character is a vertical row of bits. Tape density is 800 bits/inch (bpi). A data record for 9-track is composed of 18 to 2048 9 bit data characters followed by two redundency check characters.

The data format for 7-track tape is six data bits and one vertical parity bit for each data character. Tape densities are program selectable at 200, 556 or 800 bpi. A data record for 7-track consists of 24 to 4008 data characters followed by one redundency check character.

The magnetic tape system is the primary element for input and output of data. All source data is entered and all edited data is output on magnetic tape.

3.1.8 Storage Tube Display

The storage tube display is a Tektronix 4014-1 display terminal with the enhanced graphics option. The display is equipped with two methods of drawing vectors, normal vector drawing and incremental plot. Both methods can operate in a write and store mode or write "thru" (refresh) mode. Once the mode is selected succeeding vectors will be in the same mode.

3.1.8.1 Normal Vector Drawing

Normal vector drawing modes include dark (set point), point plot, special point plot and vector. During a set point mode, the beam is moved to a new position with no intensification. During point plot mode the beam is moved and only the end point is visible. In special point plot mode intensity of the vector is accomplished by varying the size of the stored points of the vector. A vector may be from 1 to 4095 raster units and have one of five line types available, solid, dotted, short-dash, long-dash or dot-dash.

3.1.8.2 Incremental Plot

Incremental plot provides consecutive beam movement of one raster unit vectors. Beam movement is limited to any of eight directions. Consecutive vectors are either visible or invisible. In addition an intensity change may be selected by setting the special point plot mode. Vector drawing speed is 12μs per vector.

3.1.8.3 Write-Thru (Refresh) Mode

The refresh mode allows drawing of vectors without storing and does not alter the displayed data of the write and store mode. The write-thru data is refreshed by the CPU under software control. A non-storing cursor that displays the position of the stylus of the interactive tablet relative to the data being displayed on the storage tube is generated using the write-thru mode. The presentation of the non-storing cursor on the display is for reference only and not used as an input tool. All input data is directed through the interactive tablet. Of the system's two displays the storage tube is the high capacity display. It is therefore used where vast amount of data is to be displayed. Within the editing system, it provides the means of a visual reference of an overall area partitioned as sections of a map or chart to be edited. The sections are displayed with typical cartographic data in symbolized form of roads, contours and other data called features.

Although the storage tube has a high capacity for presenting data, the speed for updating is relatively slow. For each change of display, the screen must be erased, taking ½ second, and a new picture must be plotted, taking as much as 15 seconds for a highly dense 4x6 inch display area. It is therefore not used for each iteration of change of data. It is the purpose of the refresh CRT to provide the high speed interaction necessary.

3.1.9 Lundy System 32/300 Refresh CRT

The refresh CRT is a high speed random scan display capable of drawing vectors of ½ inch or less in less than 5 micro-seconds. Updating of data in its refresh memory is performed in relatively high speed transfers in the Direct Memory Access

(DMA) mode. Some of its hardware features related to feature drawing are relative and absolute vector drawing, point vector generation, four line types of solid, dot, dot-dash and dash, four brightness levels, hardware subroutining, hardware reflection and rotation of subsets,and a character generator with four character sizes.

Its function in the editing system is to display a selected small portion of the data displayed on the storage tube to permit detailed editing at an enlarged size. Although its capacity of vectors is limited compared to the storage tube, the refresh display presents to the system a device for high speed interaction necessary for an editing system. Data transfers are in the DMA mode. Individual vectors or a string of vectors may be selectively changed without having to erase and replot the entire new image.

The stylus position of the interactive tablet is also displayed on the refresh CRT as a cursor. Again the cursor displayed on the CRT is for reference only and should not be considered an input tool.

3.1.10 Alphanumeric Keyboard

The alphanumeric keyboard is a standard 96 ASCII keyboard supplied with the Tektronix 4014-1 display terminal. Input to the system is for text data within the file structure of map data. The keyboard is also used as an additional system console for control of the editing operation.

3.1.11 Function Keyboard

The function keyboard is used for input of edit commands. It is capable of having assigned 640 commands in a configuration of 25 keys. There is one row of five alternate action pushbuttons that are used for overlay designation, resulting in 32 separate overlap, and twenty momentary pushbuttons for entering the edit command. Generating a command is performed by selecting an overlay designation and depressing a momentary key. The momentary key generates an interrupt through the refresh CRT to the CPU. The code representing the overlay and momentary keys are stored in registers in the refresh CRT to be read by the controller.

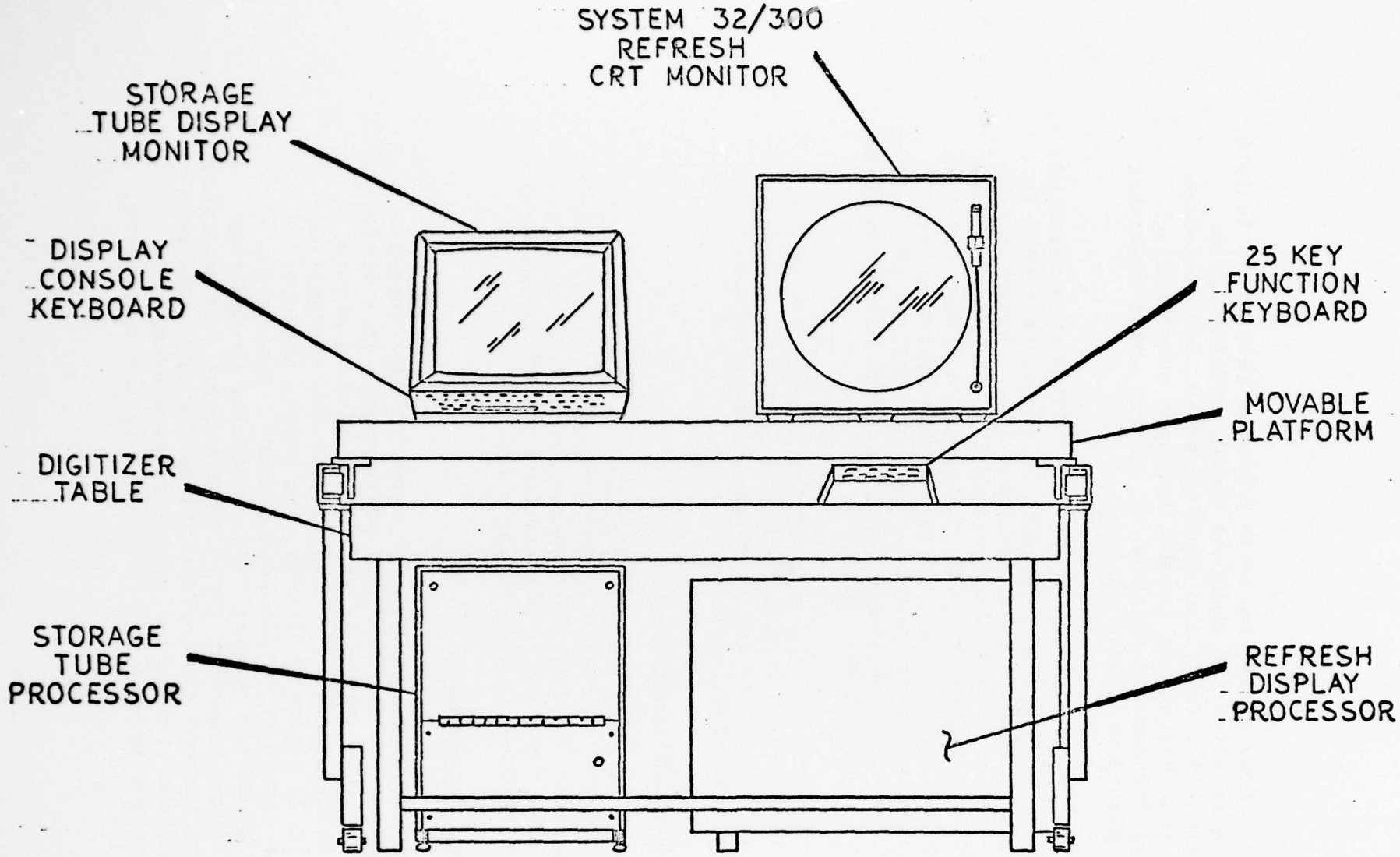


FIGURE 4

ARTIST'S CONCEPTION OF DDES WORK STATION

3.1.12 Interactive Digitizer

The digitizer is a high precision graphic input, 36x48 inch back lighted, Bendix, Datagrid Digitizer. Hardware characteristics include resolution of .001 inch, repeatability of $\pm$.001 inch and accuracy of $\pm$.0005 inch.

The rate of data input to the system is determined by two modes, time base or distance base. Time base mode is selectable recording intervals of 10 milliseconds, to 1 second. Distance base mode is selectable increment size of X and Y from 0.004 to 0.999 inch in 0.001 inch increments. The primary input of edited data is the interactive digitizer. The data is in the form of point and centerline incremental data. The stylus is always displayed on both the storage and refresh CRT through software control.

3.2 Editing Work Station

The storage CRT, refresh CRT, interactive tablet, function keyboard and alphanumeric keyboard configure a single work station as shown in figure 4. All elements of the work station are easily viewed and operated by the user.

4.0 Data File Structure

A vast amount of data is accumulated as a result of digitizing a map or chart. The data represents features (roads, railroads, etc.) in digital form. A complex sheet of many features may average 10 linear inches per square inch of incremental vectors, called Starburst vectors, having a resolution of 400 units/in. The data must be structured such that changes may be added without having to redigitize large areas of the map or chart. To accomplish this task, the sheet is first divided into equal areas called sections.

4.1 Map and Chart Section

Each section of a map or chart is 1 7/8 in. x 2 1/2 in. referenced to the size of the final product. A topographic map of a scale of 1:50,000 which is 22 in x 22 in, would have 108 sections. A source manuscript having a different scale may be rescaled during processing. Other size sheets up to 40 x 41 1/4 inch may be partitioned having a maximum of 16 rows by 22 columns of sections.

Each section is considered as an individual unit with references within its data file for continuation of features to adjacent sections. Sections are assigned a section number and row and column designation. Start and end coordinates of features are relative to the origin of the section in which they appear.

4.2 Data File Structure

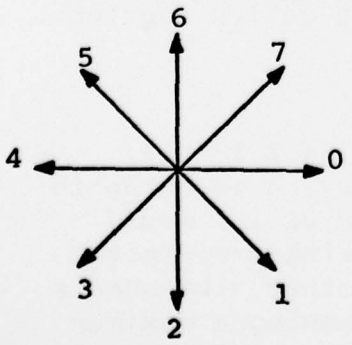
The file structure contains three basic subdivisions, which are 1. file page header, 2. feature location index, and 3. feature record. The file page header consists of 20 words of reference data including section number, row and column number, and the number of feature records within the section. The feature location index is a 250 word buffer of the addresses or location of the feature records in this file page. The feature record is variable length. It includes a feature header of 14 words that contains start and stop coordinates and tag information. The remainder of the feature record are vector codes of incremental (Starburst) vectors. The data format is shown in figure 5 and 5A.

4.3 Starburst Vector Code

The Starburst vectors are vectors describing segments of centerlines of features. The codes are packed as four codes per 16 bit word and are shown below.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	X	X	X	0	X	X	X	0	X	X	X	0	X	X	X
STAR4				STAR3				STAR2				STAR 1			

STARBURST MOVEMENT



STARBURST VECTOR	4 BIT CODE
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111

FILE PAGE FORMAT

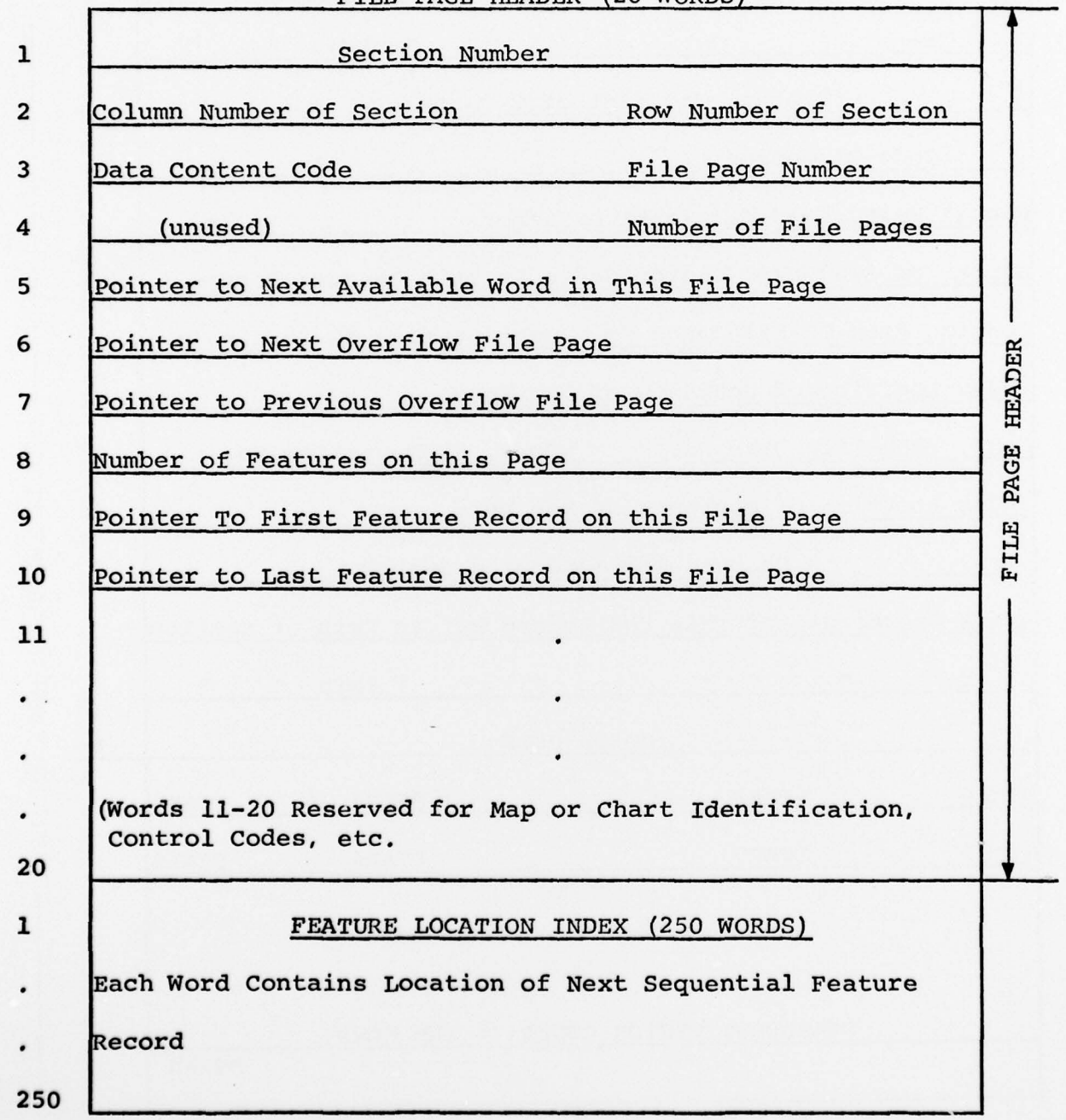


FIGURE 5

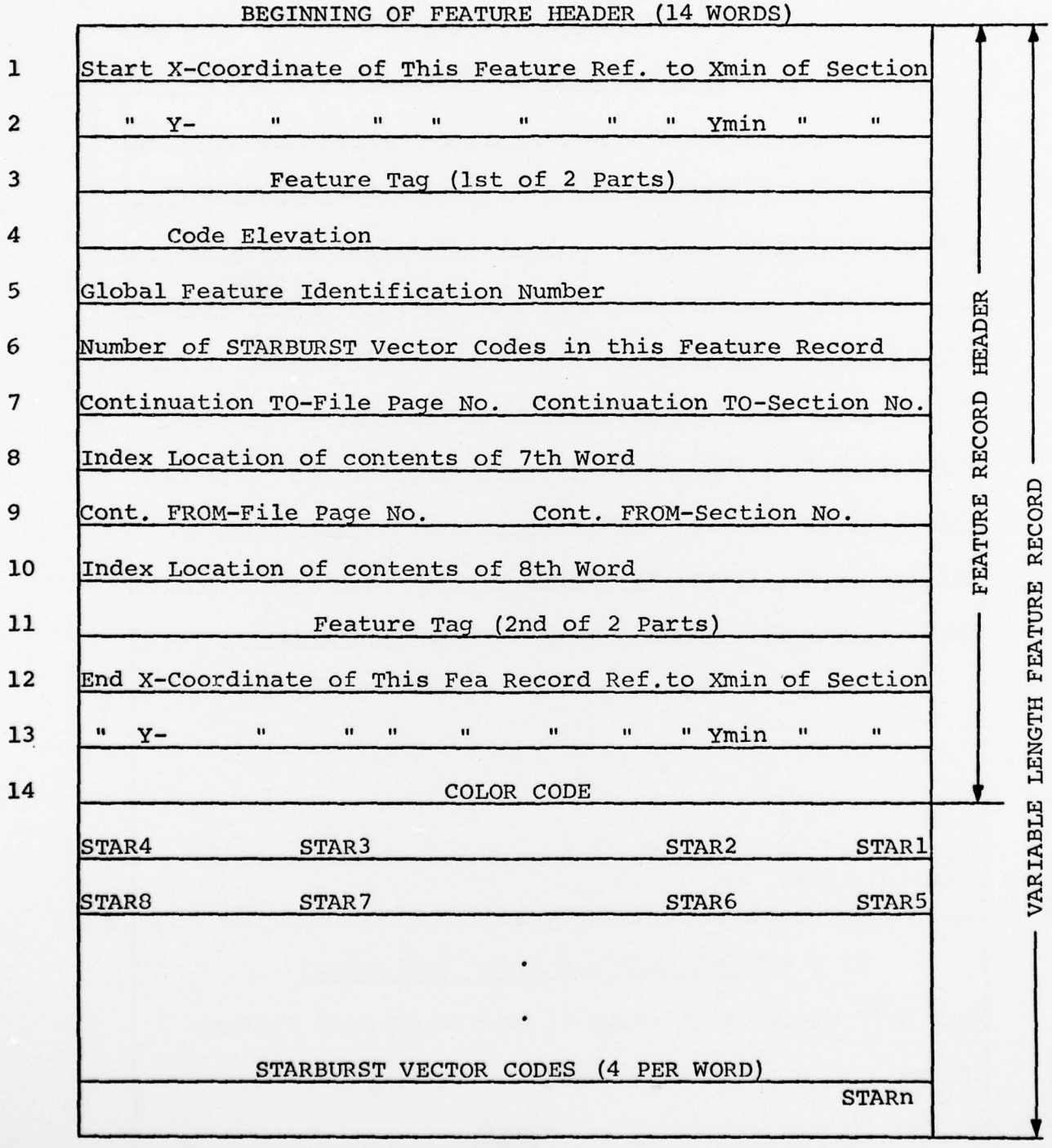

BEGINNING OF FEATURE HEADER (14 WORDS)
1 Start X-Coordinate of This Feature Ref. to Xmin of Section
2 " Y- " " " " " " Ymin " "
3 Feature Tag (1st of 2 Parts)
4 Code Elevation
5 Global Feature Identification Number
6 Number of STARBURST Vector Codes in this Feature Record
7 Continuation TO-File Page No. Continuation TO-Section No.
8 Index Location of contents of 7th Word
9 Cont. FROM-File Page No. Cont. FROM-Section No.
10 Index Location of contents of 8th Word
11 Feature Tag (2nd of 2 Parts)
12 End X-Coordinate of This Fea Record Ref.to Xmin of Section
13 " Y- " " " " " " Ymin " "
14 COLOR CODE
STAR4 STAR3 STAR2 STAR1
STAR8 STAR7 STAR6 STAR5
STARBURST VECTOR CODES (4 PER WORD)
STARn
FEATURE RECORD HEADER
VARIABLE LENGTH FEATURE RECORD
(BEGINNING OF NEXT FEATURE RECORD IN THIS FILE)

FIGURE 5A

5.0 Summary of Tests Performed

The tests performed were twofold. First, was to demonstrate the standard and special Fortran-callable peripheral subroutines operating under RSX11-D supplied with the system. Second, was to perform off line tests for testing the supplied hardware.

5.1 Lundy System 32/300

5.1.1 Lundy Graphic Subroutine Package (LGSP)

The following Fortran-callable subroutines were used in test programs to demonstrate the Lundy Graphic Subroutine Package.

Name	Description
MOVEA	absolute coordinate beam movement (no intensity)
LINEA	absolute coordinate vector with intensity
CHSIZ	allows four different character sizes
LINE	relative vector
IREC	rectangle
JUP	jump address
VSHX	vector short
SMDX	set mode (allows four line types, four intensity levels, light pen interrupts and light pen tracking)

5.1.2 Static Tests

5.1.2.1 Function Test

A program called "Function Test" was performed which tests the following characteristics of Lundy System 32/300.

Vector Generation

VECTOR SHORT
VECTOR LONG
VECTOR ALTERNATE
VECTOR ABSOLUTE
RECTANGLE
POINT VECTOR
BLINKING
4 BRIGHTNESS LEVELS
4 LINE TYPES

3D Generation

SET BINARY MULTIPLIERS

JUMP COMMANDS (Refresh memory addressing)

UNCONDITIONAL JUMP
8 CONDITIONAL JUMPS
UNCONDITIONAL JUMP AND SAVE
8 CONDITIONAL JUMP AND SAVES
JUMP BACK

Subroutine Conditions

ROTATION OF SUBPICTURES
16 PUSHDOWN LEVELS

5.1.2.2 Character Test

A program entitled "Four Character Sizes" was performed. All of the characters contained in the Standard Lundy ASCII character generator were displayed and examined for correctness.

5.1.2.3 Interrupt Tests

A program entitled "Function Keyboard Test" was performed. Each of the 25 keys of the Function Keyboard were checked to assure the correct setting of the Function Keyboard Data Register, Overlay Key Register and Interrupt Type Register. The results were printed on the console terminal.

Additional tests were performed to test the other interrupts of Light Pen, Edge Violation, Program Interrupt and Frame Interrupt. All results were printed on the console and verified.

5.2 Storage CRT Display

5.2.1 Fortran Subroutine Package

A software subroutine package, supplied by the manufacturer, entitled TCS Plot-10 was used with tests presented in the TCS Plot-10 User's Manual. The tests performed checked the following Fortran-callable routines.

Name	Description
INITT	initialization
MOVABS	absolute coordinate beam movement (no intensity)
DRWREL	relative vector
MOVREL	relative move
SDHREL	relative dashed vector
SWINDO	screen window
VWINDO	virtual window
MOVEA	absolute move outside window
DRAWABS	absolute coordinate drawing
FINITT	termination

5.2.2 Static Tests

Static tests were performed on the storage tube and tested the following features.

Character Transmission

1. shifted and unshifted characters
2. control characters
3. single, dual and triple key transmission
4. five character sizes

Graph Mode

1. dark vector
2. normal vector
3. point vector
4. five line types

5.3 Digitizer Tablet

A program called BDXTST was used to demonstrate the special digitizer I/O Handler, DG and Fortran-callable subroutine BDXDG. BDXDG is a subroutine to acquire data from the digitizer. Data is acquired by the digitizer in incremental form and is transferred to the user in absolute units or incremental form (stream data). Stream data may be formatted as three words for incremental stream or as four Starburst vectors for Starburst stream. Refer to Lundy LGSP Manual. Data was output on the line printer and checked for correctness.

5.4 Utility Routines

Special Fortran-callable utility routines necessary for data editing were also performed. These tests included tape to disk and disk to tape transfers.

5.5 Additional Testing

Additional testing will be performed at the customer's site to exercise the editing application software developed by ETL. A partial list of tests to be performed will include:

1. Pointing routines to access data for display
2. Edit routines to perform the following
    a. update feature header files
    b. delete or insert features
    c. connection of end points of features in adjacent sections
    d. change of scale.

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